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Effects of therapy on masseter activity and chewing kinematics in patients with unilateral posterior crossbite

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ABSTRACT

Objective: To describe the effects of therapy on masseter activity and chewing kinematic in patients with unilateral posterior crossbite (UPC).
Design: Fifty children (age: mean ± SD: 9.1 ± 2.3 years) with UPC (34 on the right side, 16 on the left side) and twenty children (age: 9.5 ± 2.6 years) with normal occlusion were selected for the study. The mandibular motion and the muscular activity during chewing soft and hard boli were simultaneously recorded, before and after correction with function generating bite, after a mean treatment time of 7.3 ± 2.4 months plus the retention time of 5–6 months. The percentage of reverse cycles and the percent difference between ipsilateral and contralateral peaks of the masseter electromyography envelopes were computed.
Results: Before therapy, the percentage of reverse cycles during chewing on the crossbite side was greater in patients than in controls ($P < 0.001$) and significantly reduced after therapy ($P < 0.001$) towards the reference normal value (soft bolus; pre: 57 ± 30%, post:12 ± 17%; hard bolus; pre: 65 ± 34%, post: 12 ± 13%; reference value: soft bolus 4 ± 2%, hard bolus 5 ± 3%). Before therapy the percent difference between electromyography envelope peaks in patients was lower than in controls ($P < 0.01$) and significantly increased after therapy ($P < 0.05$) becoming similar to the reference normal value.
Conclusions: The correction induced a normal-like coordination of masseter muscles activity together with a significant reduction of the reverse chewing patterns. The previous altered muscular activation corresponded to the altered kinematics of reverse chewing cycles that might be considered a useful indicator of the severity of the masticatory function involvement.

1. Introduction

Posterior unilateral crossbite is a serious asymmetric malocclusion, involving teeth, structures and functions of the stomatognathic system. It may become clinically evident at a very early stage in development, between 18 months and 5 years of age, during the eruption of the primary dentition, but it can also involve the permanent dentition at a later stage of development (da Silva Filho, Santamaria, & Capelozza Filho, 2007; Proffit, Fields, & Moray, 1998; Thilander & Lennartsson, 2002). Thus, when posterior unilateral crossbite affects children in early childhood it involves the components of the stomatognathic system that are actively developing, including motor control of masticatory function (Kiliaridis, Mahboubi, Raadsheer, & Katsaros, 2007; Nerder, Bakke, & Solow, 1999; Pinto, Buschang, Throckmorton, & Chen, 2001; Pirttiniemi, Kantomaa, & Lahtela, 1990; Thilander & Bjerklin, 2012).

Children with a unilateral posterior crossbite exhibit different types of unusual chewing patterns when chewing on the affected side, which were documented for the first time in the sixties (Ahlgren, 1967). The significant presence of reverse sequence chewing cycles, which refers to movement of the mandible during the closing phase of chewing as described later by Lewin and Ramadori (1985), has been well established in patients with

Abbreviations: UPC, unilateral posterior cross-bite; EMG, electromyography.
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crossbite, with high occurrences observed during chewing on the crossbite side only (Ben-Bassat, Yaffe, Brin, Freeman, & Ehrlich, 1993; Lewin & Ramadori, 1985; Piancino et al., 2006; Piancino, Frongia, Dalessandri, Bracco, & Ramieri, 2013; Rilo, Silva, Mora, Cadarso-Suárez, & Santana, 2007; Throckmorton, Buschang, Hayasaki, & Pinto, 2001; Wilding & Lewin, 1994). Reverse chewing cycles show an abnormal, narrow kinematic pattern in the frontal plane, characterized by cross over of the tracings and limited lateral displacement of the mandible in comparison with the pattern of the non-affected side, which shows physiological morphology. As a result there is a serious asymmetry of the masticatory function (Lewin & Ramadori, 1985; Piancino et al., 2006; Sever, Marion, & Ovsenik, 2011).

Mirroring the kinematic pattern, the activation of the masseter muscles is altered and subjects with unilateral posterior crossbite show marked differences between sides resulting in an asymmetrical activation of the masseter muscles during rest, maximal clenching, and swallowing (Andrade, Gavião, Gameiro, & De Rossi, 2010; Ferrario, Sforza, & Serrao, 1999; Martín, Palma, Alamán, Lopez-Quiñones, & Alarcón, 2012; Piancino, Farina, Talpone, Merlo, & Bracco, 2009). Moreover during unilateral chewing on the side of crossbite, children with unilateral posterior crossbite show decreased activity of the masseter on the crossbite side and increased masseter activation on the contralateral side during reverse cycles (Piancino et al., 2009). This results in a reduced side to side difference in masseter muscle activity in children with unilateral posterior crossbite, whereas normally, unilateral chewing is characterized by a significant difference in activation between the ipsilateral and contralateral masseter muscle (Piancino, Bracco, Vallelonga, Merlo, & Farina, 2008).

It remains unknown whether functional therapy, which has been shown to correct reverse chewing cycles(Piancino et al., 2006), can re-establish the normal coordination between the bilateral masseter muscles during chewing. That is, whether functional therapy can induce an increase in activation of the ipsilateral masseter or decrease in contralateral masseter activity so that the difference in bilateral masseter muscle activation resembles that of control subjects. This knowledge is important to appreciate whether repositioning of the teeth within the dental arches can improve neuromuscular control of chewing (Johnsen & Trulsson, 2005; Lund, Scott, Kolta, & Westberg, 1999; Morquette et al., 2012; Quintero et al., 2013; Woda et al., 2010).

This study describes the effect of the functional therapy delivered at our center on both kinematic chewing patterns and masseter muscle coordination in patients with unilateral posterior crossbite.

2. Materials and methods

Fifty children (age: mean ± SD: 9.1 ± 2.3 years) with unilateral posterior crossbite (34 on the right side, 16 on the left side) and twenty children (age: 9.5 ± 2.6 years) with normal occlusion, referring to the Orthodontic Department of the University of Turin, Italy, from January 2011 through April 2014, were selected for this observational study. Before participating in the study, informed consent was obtained from the parents and the study was approved by the Institutional Review Board of the University Hospital "Health and Science Complex Turin-Italy" n. CS/246, in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

The inclusion criteria for the patients group were: (i) unilateral posterior crossbite of two or more posterior teeth, (ii) mixed dentition. The exclusion criteria were the presence of (i) previous orthodontic therapy, (ii) erupting teeth, (iii) caries, (iv) dental pain.

A parallel control group was carefully selected for normal occlusion and mixed dentition, and was matched with the patient group for age and gender.

Casts in maximal intercuspation and orthopantomography were obtained from all subjects and patients to classify, respectively, the type of crossbite and the erupting teeth.

The recordings of chewing cycles were carried out immediately before the intervention and after correction plus the retention time, whereas the control group was measured twice with a time span of six months. Both cases and controls data were analyzed in the same time period.

2.1. Appliance

Each patient was treated with the functional appliance 'Function Generating Bite' (Fig. 1). The appliances were individually manufactured and made of acrylic resin and special resilient stainless steel, with posterior metallic bite planes preventing the teeth from intercuspal contacts. The appliance is characterized by a

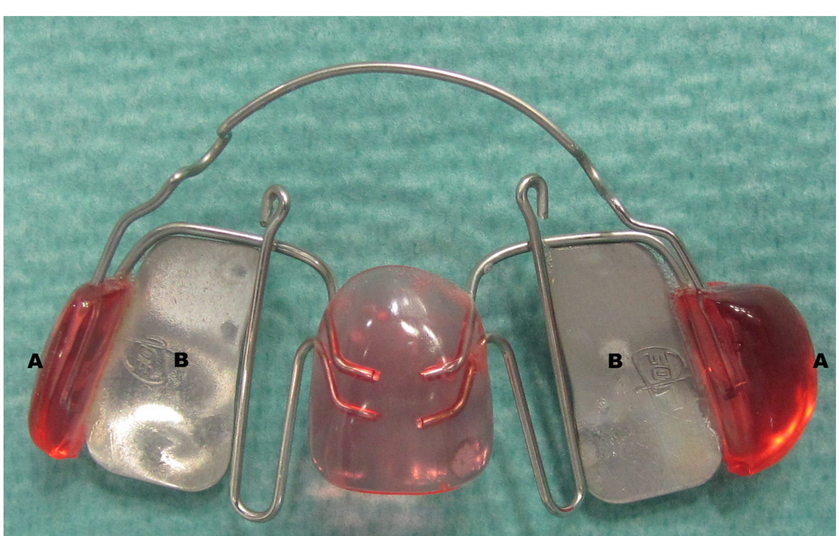

Fig. 1. The Function Generating Bite appliance, upper view. The resilience of the bite planes (B) and the elasticity of the wires of the appliance permit the orthodontic movement of the teeth avoiding dental trauma. Due to the muscular anchorage the different thickness of the buccal shields (A) lets the application of different forces between sides to correct the asymmetric malocclusion.